Space Weather Technical Forecast

Issued on Saturday, 01 June 2024 at 12:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: High activity with further M-class or X-class flares likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with two X-class flares observed, X1.4 at 01/0848 UTC and X1.1 at 31/2203 UTC, both from AR3697 on the southeast disc. Despite being much reduced from its previous incarnation as AR3664 on the last rotation, this remains a moderately sized region, with a persistent delta spot within its leader. Some ongoing penumbral growth has also been observed. There are seven numbered regions with ongoing growth also observed in AR3698 in the northeast and AR3699, just west of north-centre, however these remain simple bipolar groups. AR3691 in the northwest continues to gradually simplify, breaking into smaller component spots.

No Earth-directed CMEs were visible in available imagery, with neither X-flare appearing to be eruptive. A disappearing solar filament (dsf) was also observed in the northeast disc, however no subsequent CME has been identified. There are a number of other filaments on the disc, including two large filament across the southern hemisphere that will be monitored for any potential lift.

Solar Wind / Geomagnetic Activity: Observations by ACE showed speeds persisting at background at 330-370 km/s, with density largely below background, but with brief periods of nearer average values, most notably after 01/0936 UTC. These density changes could perhaps be related to a very slight glance from the missing CME of the X1.4 flare on 29 May, however this is very uncertain. Interplanetary Magnetic Field, Bt, was generally weak, 3-7nT with the north-south component, Bz, predominately negative (southward), and ranging between +3 to -5nT. Phi angle was generally negative (towards the Sun), but rotated to be slightly positive (away from the Sun) after 01/0936 UTC. Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 remained at background levels with no solar radiation storms occurring. High energy electron flux (greater than 2MeV) at GOES16 was at background with the associated 24-hour fluence below the Active threshold. Observed fluence at 01/0000 UTC was 1.78e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity with further occasional M-class or X-class flares expected, mainly from AR3697 in the southeast.

Solar Wind / Geomagnetic Activity: Weak CME from the C7.5 flare of AR3698 and subsequent nearby coronal dimming on 31 May is expected either late day 2 or early day 3 (02-03 Jun), although confidence is low with the strength of any arrival due to the faint and weak nature of the CME. Otherwise background winds are likely to persist, with a chance of becoming slightly enhanced for a time later day 1 or day 2 (01-02 Jun) with any onset of the fast wind of small CH42/+, however this is also low confidence. Mainly Quiet geomagnetic activity is expected, with chance of rising to Unsettled or Active with either of these enhancements. There

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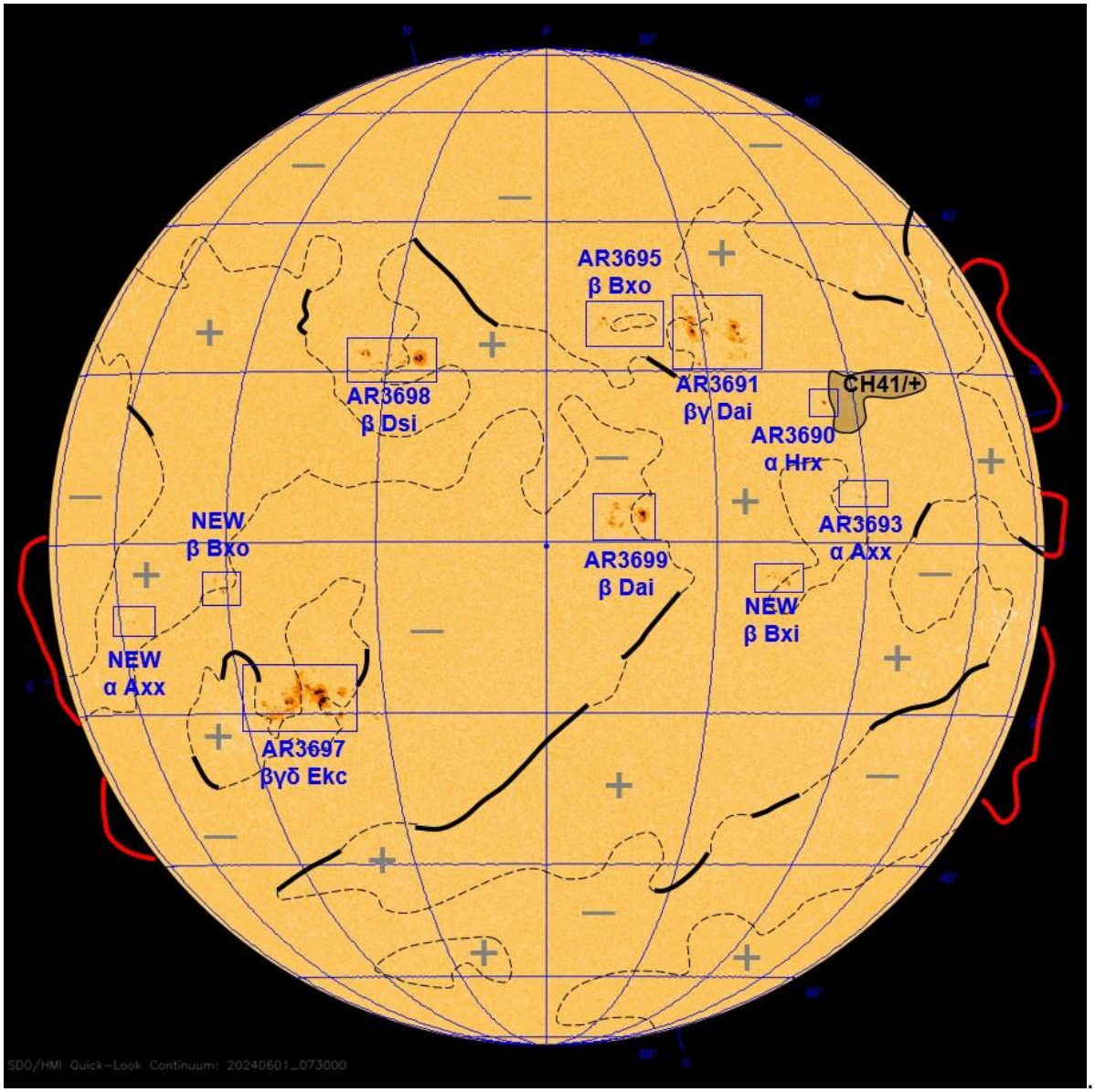
is a slight chance of an isolated G1 Minor Storm intervals.

Energetic Particles / Solar Radiation: High energy proton flux is expected to persist at background, but with a slight but increasing chance of rising above the S1/Minor Storm threshold given any further notable flares. High energy electron flux is forecast to persist at background, with the associated 24 hour fluence forecast to remain below the Active threshold.

Figure 1. Solar Analysis Valid 01/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

CME from the X1.4 flare of AR3697 on 29 May has likely passed Earth. A further faint partial halo CME was observed on 30 May, perhaps from the C7.5 flare of AR3698 and subsequent nearby coronal dimming around 30/0500 UTC. This is very low confidence, due to the indistinct nature of the CME on imagery, but brings a likely weak arrival late on day 2 or early day 3 (02-03 Jun).

Otherwise, current slightly elevated solar winds may see a very weak enhancement from CH41/+, becoming slightly elevated later day 1 or day 2 (01-02 Jun), before easing to background. This feature is currently overestimated in current MOSWOC Enlil, leading to reduced confidence in both any potential connection, but also in the previous CME forecasts.

There are also a number of large filaments currently on the Earth-facing disc, and these will be monitored for any potential Earth-directed eruption.

Geomagnetic activity is forecast to be mainly Quiet, but increasing to Unsettled to Active with any fast wind onset day 1-2 (01-02 Jun) or CME arrival day 2-3 (02-03 Jun). These bring a slight chance of G1 Minor Storm intervals throughout, and a slight risk is maintained on day 4 (04 Jun), given the recent activity on the disc and the potential for further CMEs.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/1205 UTC	Partial	C7.5 and coronal dimming	NE	710km/s	03/0300 +/- 12hrs	Updated analysis. Low confidence and faint in imagery

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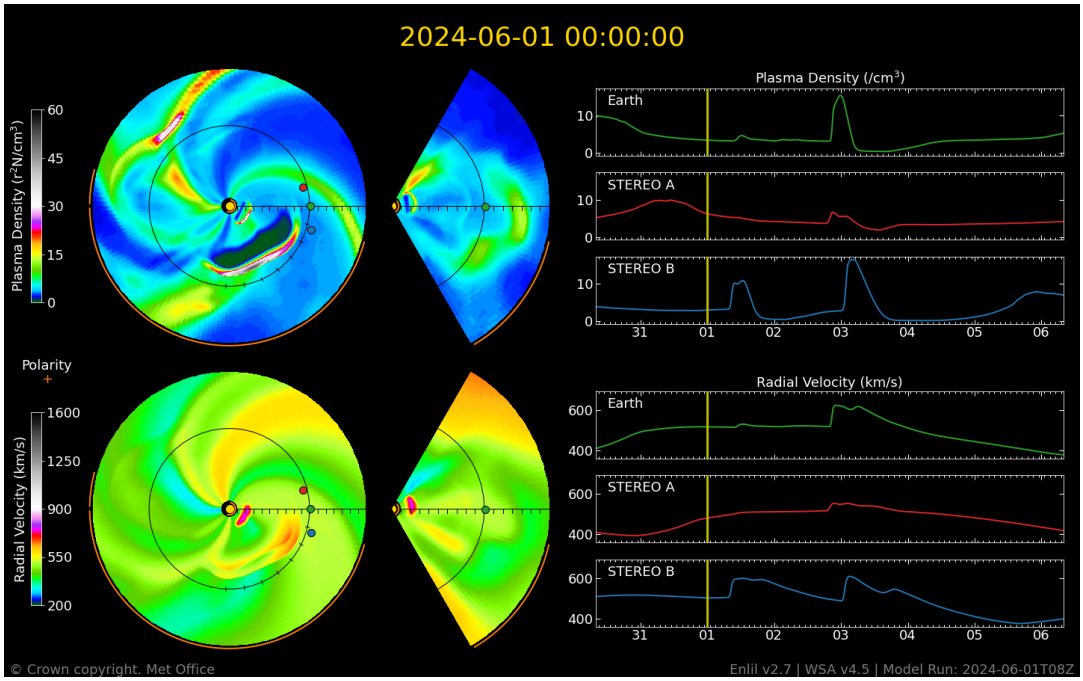
Figure 2a: Enlil and Ensemble



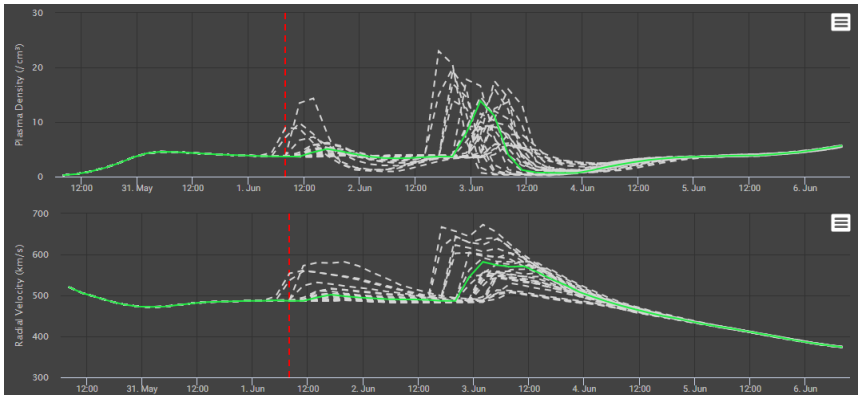
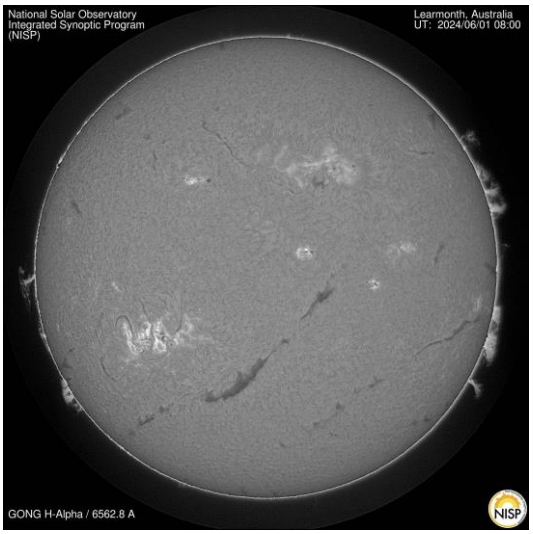


Figure 2b: H-alpha imagery showing number of large filaments on Earth-facing disc



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Radio Blackouts - X-Ray Flares:

Solar activity is currently High, and expected to remain Moderate to High through the period, with the potential for occasional M or X-class flares, predominately from AR3697.

There are seven numbered sunspot regions on the disc, along with a couple of further emergent regions. The majority of the activity is associated with AR3697, which persists as a moderately sized and complex spot on the southeast disc. While reduced in size and complexity compared to the last rotation (as AR3664), this region has still produced four X-class flares since being observable on the east limb. This region has seen some recent growth in areal extent, and there is a strong delta spot within its leader, albeit rather small. While this persists there will remain the potential for X-class flares, and an isolated flare exceeding X10 (R4 Blackout) cannot be completely ruled out.

Some growth has also been observed across the rest of the disc, with AR3698 in the northeast and AR3699 in the northwest developing in the last 24-48 hours, however these have matured into relatively simple bipolar configurations. AR3691 also persists in the northeast disc, however this has a simplifying trend, losing its previous delta-configuration and breaking into small component spots.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	75	70	60
Very Active	R3 to R5 X Class	Yes	40	40	30	25

Figure 3a: GOES-16/18 X-ray flux

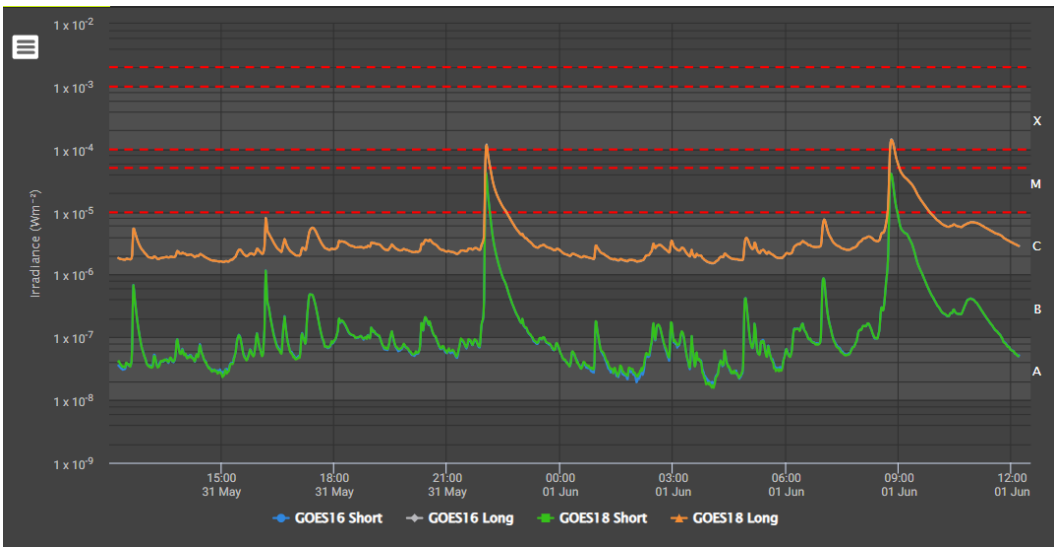

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Figure 3b: SDO imagery of AR3697

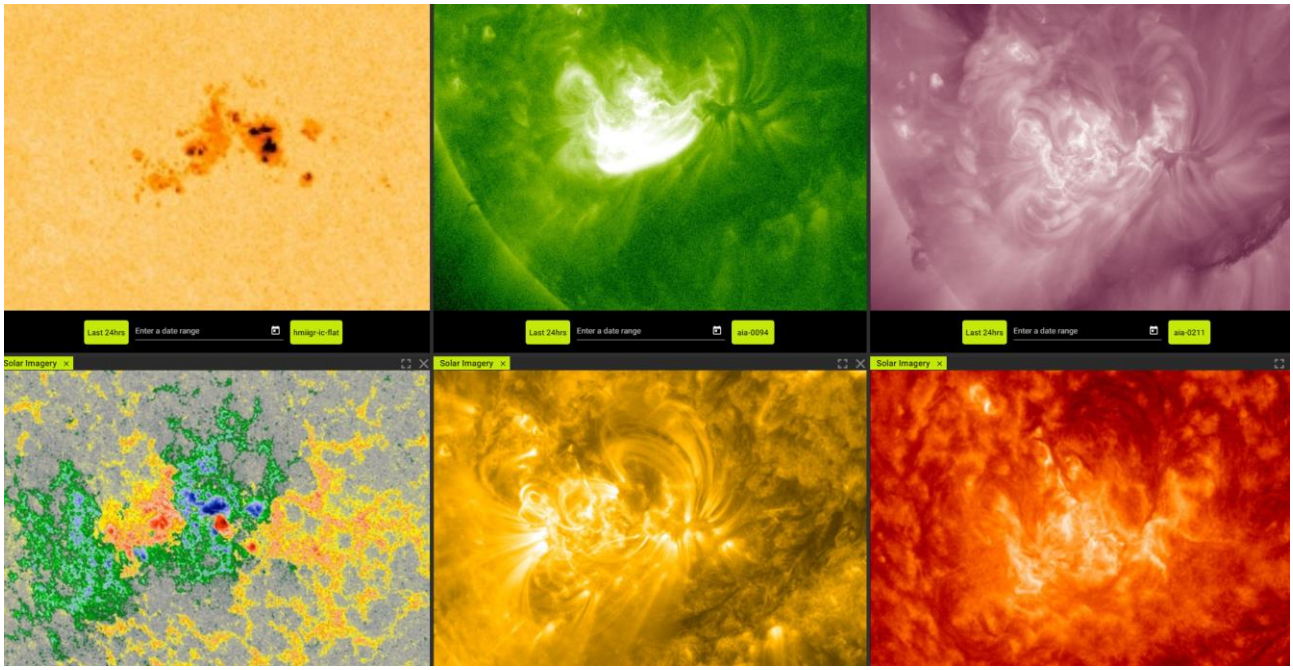
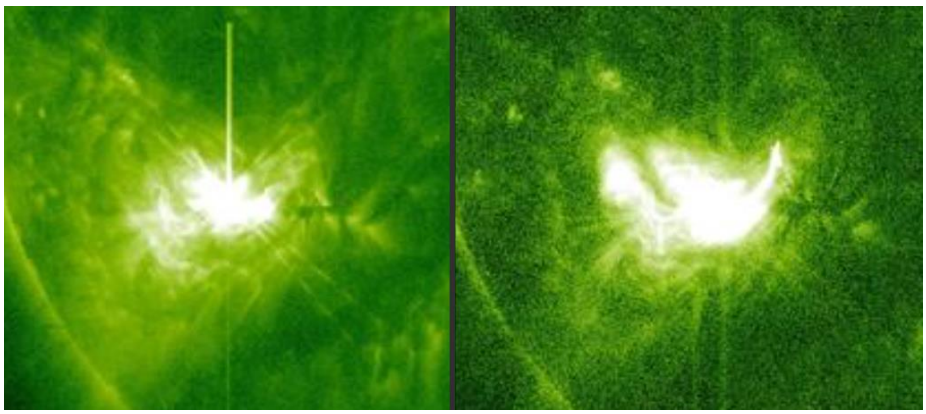


Figure 3c: SDO aia-94 showing X-1.1 flare and X1.4 flare of AR3697



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Solar Radiation Storms - (High Energy Protons):

GOES-18 high energy proton flux is currently at background, with no response observed from the X-flares of AR3697 on 31 May and 01 Jun. This region, however, continues to have the potential for stronger X-flares, and also has a continuously improving location for any such flares to eject Earth-directed high energy protons. Despite this improving location, the confidence in the longevity of the flare risk from the region does slightly fall through the period. These two factors balance to give an overall slight chance of proton flux enhancement occurring and reaching the S1 Minor Storm threshold. Given the potential for stronger flares, it also cannot be completely ruled out that any such proton storm could exceed the strong threshold (S3 Strong radiation storm).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux, as observed by GOES-16, is expected to persist at mainly background, with no notable sources of potential enhancement currently anticipated. The associated 24 hour electron fluence is expected to remain below the Active level, as supported by MOSWOC REFM, which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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